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(6) References	Laid-open Patent Application Showa 62-77728 (JP, A) Laid-open Patent Application Showa 62-108632 (JP, A) Laid-open Patent Application Showa 51-112210 (JP, A) Laid-open Utility Model Application Heisei 3-56243 (JP, U)

(54) [Title of the Invention] DIVERSITY SYSTEM

(57) [Patent Claims]

[Claim 1] A diversity system characterized in that in a wireless packet communication system composed of a data transmitter and a data receiver, each being provided with a transmission unit and a reception unit, at least said data transmitter comprises a plurality of transceiver antennas and means for deciding whether an identification signal was returned from the data receiver when data were transmitted from one of said antennas, and if said identification signal was not detected, the data transmitter switches the data transmission to another antenna.

[Detailed Description of the Invention]

[Field of Industrial Application]

The present invention relates to an improved diversity system for a wireless packet communication system.

[Essence of the Invention]

In a diversity system based on switching antennas in wireless packet communication at the data transmission side, the antennas at the data transmission side are switched when an ACK signal (identification signal indicating the correct reception) from the data reception side has not been received correctly.

[Prior Art Technology]

Fig 10 and Fig 11 illustrate examples of conventional diversity systems. In Fig 10, the reference symbol 101 stands for a transmitter, 102 – transmitting antenna, 103 and 104 – receiving antennas, 105 and 106 – high-frequency circuit units, 107 – reception state comparison circuit, 108 – switch, 109 – demodulation circuit. Furthermore, in Fig 11, the reference symbols 201, 202 stand for receiving antennas, 203 – high-frequency circuit unit, 205 – reception state comparison circuit, 204 – switch, 206 – demodulation circuit.

At the reception side shown in Fig 10, the reception is conducted with two antennas 103 and 104, the – reception state comparison circuit 107 decides which of the antennas made better reception, and the antenna with better reception is selected by the switch 108. Because of a large scale of high-frequency circuit unit 105, 106 in the system shown in Fig 10, a system shown in Fig 11 has also found application. In the system shown in Fig 11, the reception is first conducted with antenna 201 and if the reception state is degraded, a decision is made by the reception state comparison circuit 205 and switching is made to antenna 202.

[Problems Addressed by the Invention]

When any of the above-described systems is used, a control circuit, such as circuit 107 or circuit 205, is required for switching the switch, and when the control is conducted with a microcomputer, it is necessary to provide an appropriate sensor circuit. Other problems are associated with the fact that performance also greatly depends on the control circuit or sensor and the design is difficult.

[Object of the Invention]

It is an object of the present invention to provide a diversity system used in wireless packet communication, which does not require a special control circuit for antenna switching.

[Means to Resolve the Problem]

In order to attain the above-described object, the present invention provides a diversity system characterized in that in a wireless packet communication system composed of a data transmitter and a data receiver, each being provided with a transmission unit and a reception unit, at least the data transmitter comprises a plurality of transceiver antennas and means for deciding whether an identification signal was returned from the data receiver when data were transmitted from one of the antennas, and if the identification signal was not detected, the data transmitter switches the data transmission to another antenna.

[Operation]

If a data signal transmitted from one antenna of a data transmitter is correctly received by a data receiver, an identification signal (ACK) is sent from the data receiver to the data transmitter.

When the data transmitted does not receive the identification signal, it switches antennas and data transmission is conducted from another antenna.

[Embodiment]

An embodiment of the present invention will be described below with reference to the drawings attached. Prior to the description of the embodiment, packet communication will be briefly explained. Fig 2 illustrates the simplest protocol of packet communication between station A and station B. In packet communication, data which are to be transmitted are divided into small segments, a header such as data number, address and the like is attached to each segment, and transmission is conducted in packets.

In the system shown in Fig 2, station A transmits a first package (data), station B correctly receives the package and returns an ACK signal which is correctly received by station A. In station A, a timer is started from the moment of data transmission and the time T to ACK reception is monitored. When T reaches a preset time T_w , a decision is made that the propagation path is faulted and the same package (data) is retransmitted. In Fig 2, T_1 is shorter than T_w . Therefore, the first package (data) is not retransmitted.

Then, a second package (data) is transmitted from station A. Let us assume that it is not received by station B because of the propagation path fault. In this case the ACK signal is sent and T_2 reaches T_w . As a result, station A resends the second package (data). In the system shown in Fig 2, the ACK signal was correctly received in response to the retransmitted signal.

Fig 2 illustrates a case in which the propagation path fault occurred in signal transmission from station A to station B. However, similar retransmission is conducted if the fault occurred when the ACK signal was transmitted from station B to station A, or when station A did not receive the ACK signal. In such cases, station B again receives the package (data) of the same content, which by itself causes no problems.

The protocol of packet communication which is actually implemented is more complex, but the basic approach based on using the ACK signal and retransmission is common for all T packet communications.

The diversity system in accordance with the present invention provides an improvement over the wireless packet communication of such protocol. An embodiment of the present invention is shown in Fig 1. In this figure, the reference symbols 401 and 402 stand for antennas, 403 – antenna switch, 404 – transmission-reception switch, 405 – transmission unit, 406 – reception unit, 407 – microcomputer.

Microcomputer 407 conducts diversity control and protocol control other than diversity, for example, packeting of transmitted data and inverse packeting of received data. Antenna switch 403 is a specific control object of diversity. Transmission-reception switch 404 is also the control object of microcomputer 407. However, such control is conducted only to the transmission side T during transmission and to reception side R during reception and does not represent a structural feature of the present invention. Accordingly explanation thereof is omitted.

Fig 3 illustrates the operation of the above-described embodiment based on the model shown in Fig 2. As shown in Fig 3, when the ACK signal is not received in response to data transmission, the connection of antenna switch 403 to one antenna is switched to another antenna and data are retransmitted. Fig 3 illustrates a case in which the ACK signal relating to the second packet (data) was not received and therefore the antennas were switched. In this case, because the propagation path was good, data transmission was completed correctly with a single retransmission. The operation of system shown in Fig 3 is illustrated with a flow chart in Fig 4 as a typical operation of microcomputer 407. In the control by microcomputer 407, the stage 601 in Fig 4 corresponds to initial state in which the antenna switch 403 is connected to one antenna. Then a decision is made of whether the data are to be transmitted or received (step 602). If data are to be received, a decision is made of whether the reception is conducted (step 612). If YES, then ACK transmission and data processing are conducted (step 613).

If in step 602 a decision is made that data are to be transmitted, then via data processing in step 603 packets $K = 1 \sim K$ are transmitted (steps 604, 605), and a timer is started (step 606).

If then the reception of ACK is confirmed (step 607) and a YES decision is made, the transmission is completed (step 610) and the program returns to step 602 or to step 605, assuming that $K = K + 1$ in step 607. If the decision in step 607 is NO, then a decision is made of whether the timer count has reached T_w (step 608). If NO, then the program returns to step 607, and if YES, then the antenna switch 403 is switched to another antenna (step 609) and the program returns to step 605.

The above-described operations relate to a case in which antenna switching was made only at the data transmission side. With such operations, when, as shown in Fig 5, the data flow is only from station A to station B (or mainly from station A to station B) and it is not necessary to conduct diversity in station B, or the diversity in station B is impossible for some reason (for example, because two antennas are not used), then route 1 is switched to route 2 in station A and a good propagation path is selected. Furthermore, as shown in Fig 6, even when both the station A and the station B have the diversity function, since the control right is only at the data transmission side (Fig 6 illustrates a case in which data are transmitted from station A), switching between route 1 and route 2, or switching between route 1' and route 2' can be conducted in station A. However, when both the station A and the station B have the diversity function, as shown in Fig 7, four propagation paths (route 1 ~ route 4) can be selected. Such configuration is more effective because a larger number of propagation paths can be selected.

To conduct operations illustrated by Fig 7, microcomputer operations, such as antenna switching, also may be conducted at the ACK transmitting side.

Fig 8 shows a flow chart of operations of the embodiment relating to this case. In this figure, steps 601, 602, 612, 613 are identical to those shown in Fig 4. Operations of steps 1001, 1002, 1003 are added.

Thus, if data are received, a decision is made of whether K is the same (step 1001). If NO, then the program proceeds to step 613. If YES, then if the number of retransmission cycles is no less than M (step 1002), the antenna switch 403 is switched to another antenna (step 1003).

In Fig 8, K is the number of transmitted data; it corresponds to K in step 605 of Fig 4 and is transmitted upon inclusion in the header. The number of retransmission cycles in station A is also included in the header and transmitted together with the data. M in step 1002 may be determined appropriately at no less than two. With such operations, as shown in Fig 3, four routes shown in Fig 7 can be selected when ACK is hindered and not received by station A.

Fig 9 illustrates an example of operation conducted in the expanded diversity system following the flow chart shown in Fig 8. In Fig 9, in $[\alpha, \beta]$ of station A, α stands for the number of retransmission cycles and β stands for an antenna (A-1 or A-2) used in station A. The symbol in parenthesis [...] relating to station B represents an antenna (B-1 or B-2) used in station B, DK stands for K-th data, and X stands for a fault. With the system shown in Fig 9, when the optimum propagation path is represented by combination of antennas A-2 and B-2, this path can be reached by the conducted operations. Furthermore, Fig 9 illustrates a case in which M in step 1002 shown in Fig 8 is 2.

Well known technologies such as space diversity, polarization diversity, directivity diversity and the like can be used as the diversity of antenna switching in accordance with the present invention. Furthermore, the explanation above was conducted with respect to two antennas. However, when there are three or more antennas, step 609 shown in Fig 4 and step 1003 shown in Fig 8 may be implemented as successive switching steps rather than "switching to another antenna". System with a large number of antennas is more effective in terms of providing an opportunity of selection of a large number of propagation paths.

In the above-described embodiment, a microcomputer was used. However, a microcomputer is a proper means for protocol control in packet communication and from the standpoint of hardware a low-cost and high-performance diversity system can be realized because a large number of antennas and antenna switching circuits may be used without using a switching control circuit, as in the conventional system.

[Effect of the Invention]

As described above, the present invention can provide a diversity system suitable for inexpensive high-performance wireless packet transmission.

[Brief Description of the Drawings]

Fig 1 is a block diagram illustrating an embodiment of the present invention. Fig 2 is a diagram explaining the packet communication. Fig 3 is a diagram explaining the operation of the above-mentioned embodiment. Fig 4 is a flow chart illustrating the operation of a microcomputer in the embodiment. Figs 5, 6, and 7 illustrate the selection of propagation path in the embodiment. Fig 8 is a flow chart illustrating the operation of another embodiment of the present invention. Fig 9 is a diagram illustrating the operation of the above-mentioned another embodiment. Fig 10 and 11 are block diagrams illustrating the conventional diversity systems.

401, 402 – antennas, 403 – antenna switch, 404 – transmission-reception switch, 405 – transmission unit, 406 – reception unit, 407 – microcomputer.

Fig 1

401, 402 – antennas, 403 – antenna switch, 404 – transmission-reception switch, 405 – transmission unit, 406 – reception unit, 407 – microcomputer.

Fig 2

Station A

First packet (data) is transmitted
ACK is received
Second packet (data) is transmitted
ACK could not be received.
Second packet (data) is retransmitted
ACK is received

Fault

Station B

First packet (data) is received
ACK (identification signal indicating the correct reception) is transmitted
Second packet (data) cannot be received.
ACK cannot be sent
Second packet (data) is received
ACK is transmitted

Fig 3

Station A

403 is set at α side

First packet (data) is transmitted

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ACK is received
Second packet (data) is transmitted
ACK cannot be received
403 is set to β side
Second packet (data) is retransmitted
ACK is received
Third packet (data) is transmitted
ACK cannot be received
403 is set to α side
Third packet (data) is retransmitted

Fault
Fault

Station B

First packet (data) is received
ACK is transmitted
Second packet (data) cannot be received correctly
ACK is not sent
Second packet (data) is received
ACK is transmitted
Third packet (data) is received
ACK is transmitted

Fig 4

601 : Antenna switch SW (403) is set to initial state
Transmission
602 : Data transmitted or received?
Reception
603 : Data processing
605 : K-th packet (data) is transmitted (retransmitted)
606 : Timer start
607 : Could ACK be received?
608 : Has timer reached T_w ?
609 : Antenna switch SW (403) is switched to another antenna
610 : Transmission completion
612 : Were data received?
613 : ACK transmission and data processing

Fig 5
Station A
Station B

Fig 6
Station A
Station B
Route 1
Route 1'
Route 2

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Route 2'

Fig 7
Station A
Station B
Route 1
Route 1'
Route 2
Route 2'

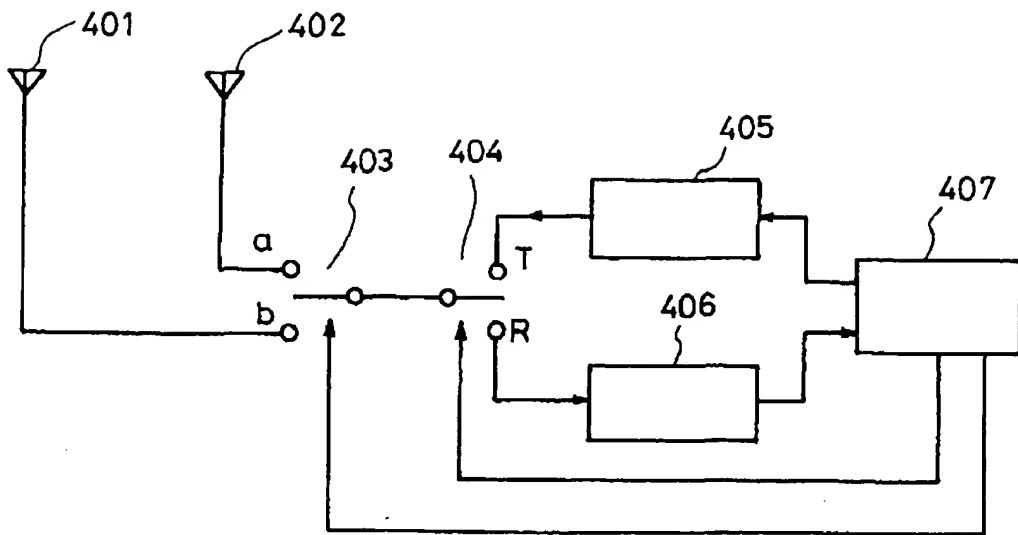
Fig 8

Transmission
Reception
1001 : Is K the same?
1002 : Is the number of retransmission cycles no less than M?
1003 : Antenna switch SW (403) is switched to another antenna

Fig 9
Station A
Station B

Fig 10
Transmitting side
Receiving side

【第1図】



401, 402: アンテナ

403: アンテナ切替スイッチ

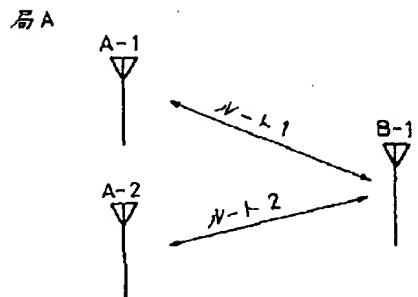
404: 送受切替スイッチ

405: 送信部

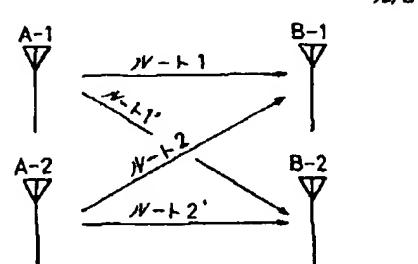
406: 受信部

407: マイコン

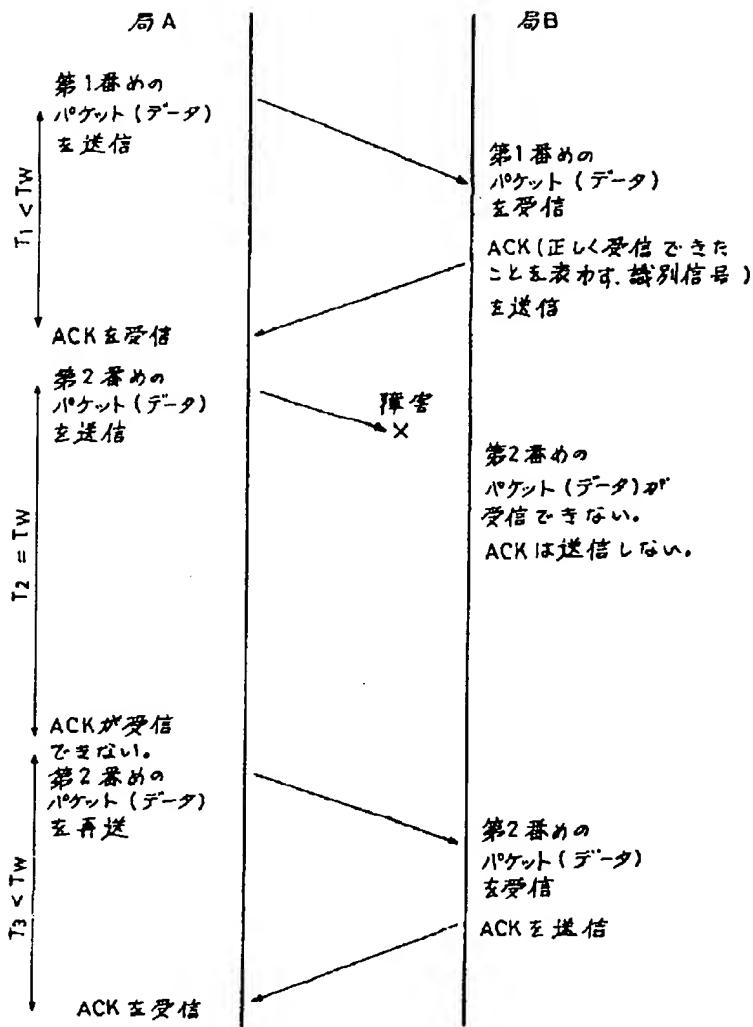
【第5図】



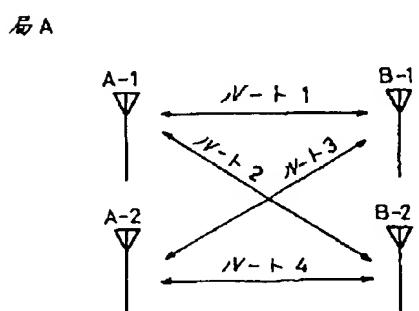
【第6図】



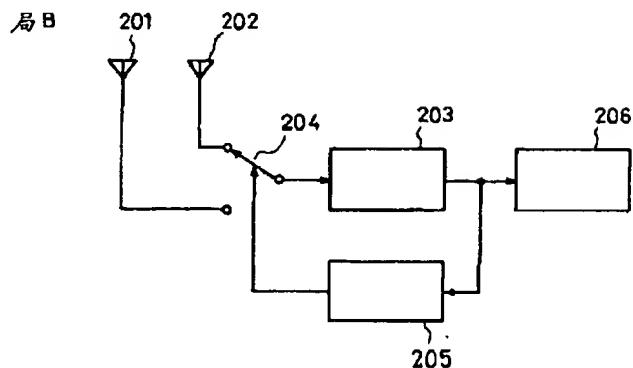
【第2図】



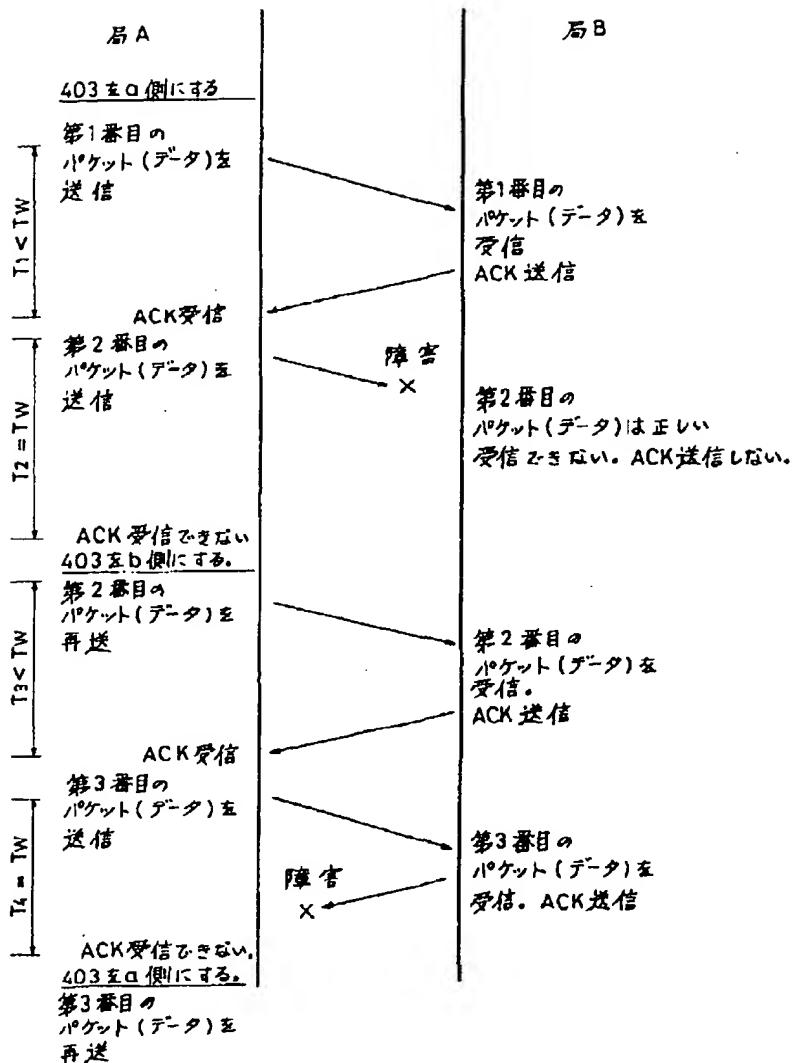
【第7図】



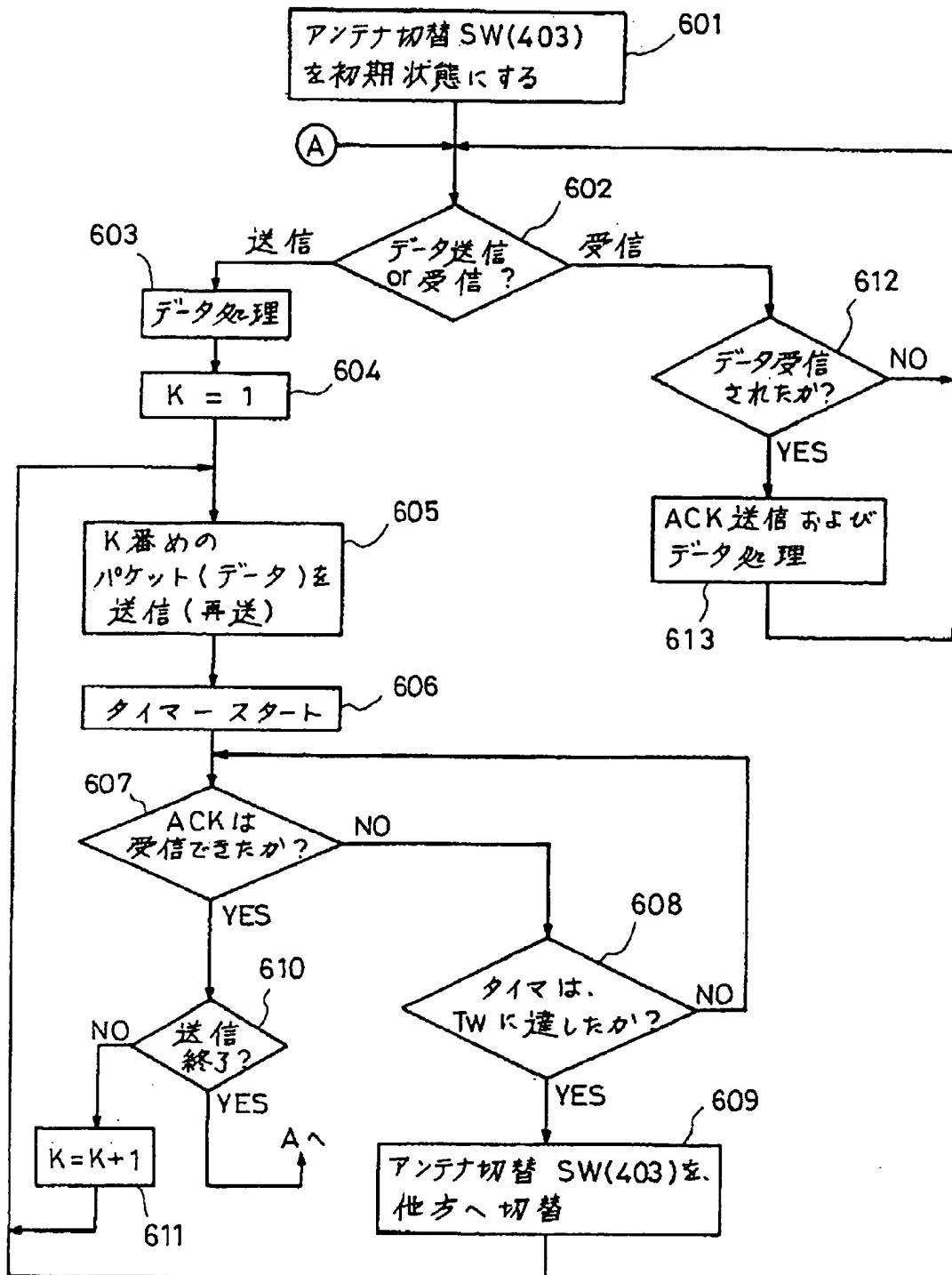
【第11図】



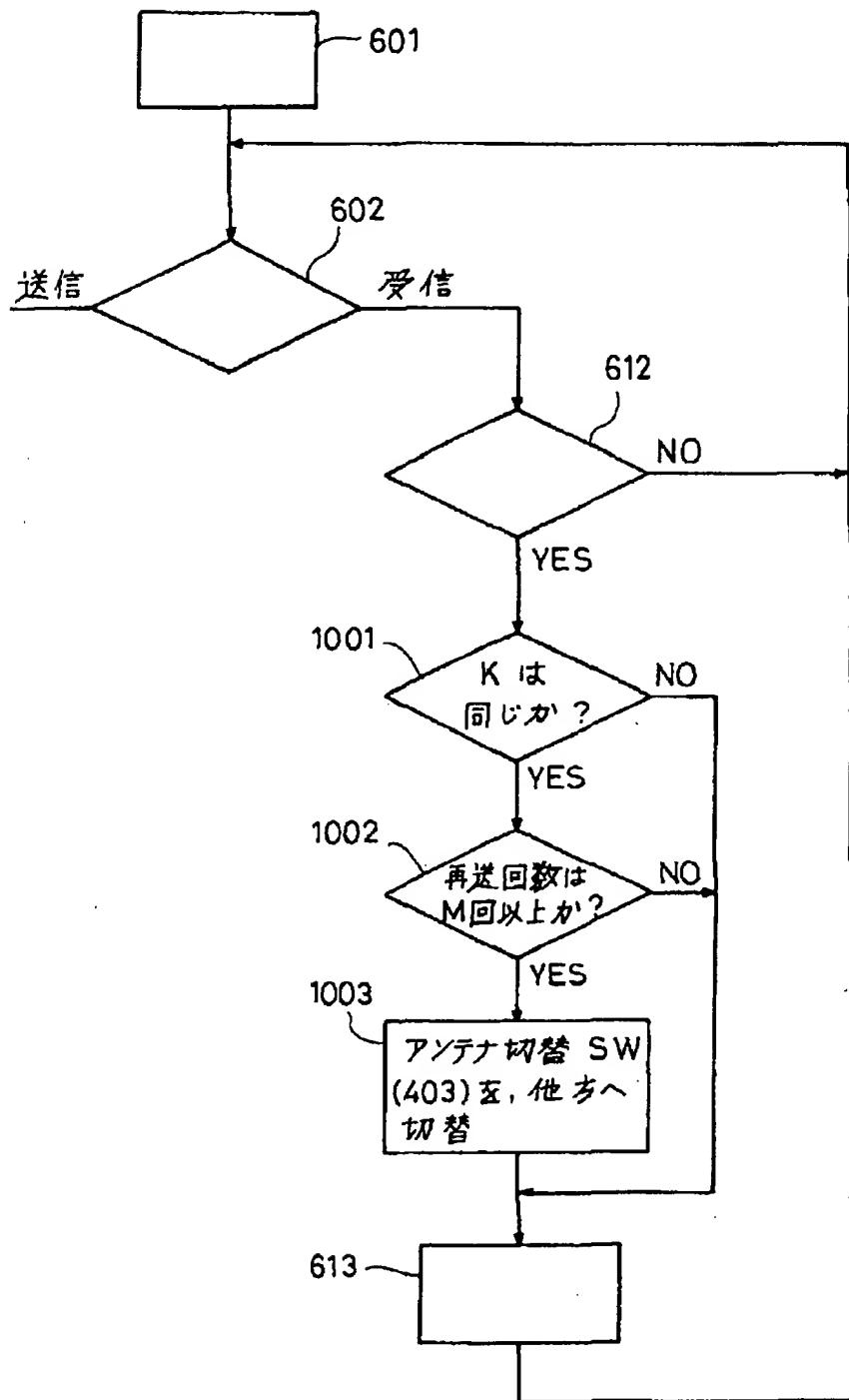
【第3図】



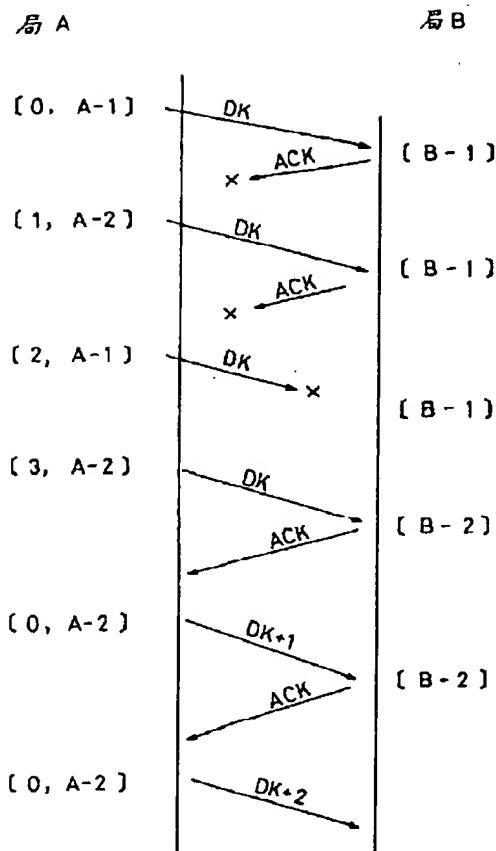
【第4図】



【第8図】



【第9図】



【第10図】

